(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 July 2003 (24.07.2003)

PCT

(10) International Publication Number
WO 03/060288 A1

(51) International Patent Classification⁷: E21B 33/064, 29/12

(21) International Application Number: PCT/NO03/00011

(22) International Filing Date: 15 January 2003 (15.01.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
20020233 16 January 2002 (16.01.2002) NO

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,

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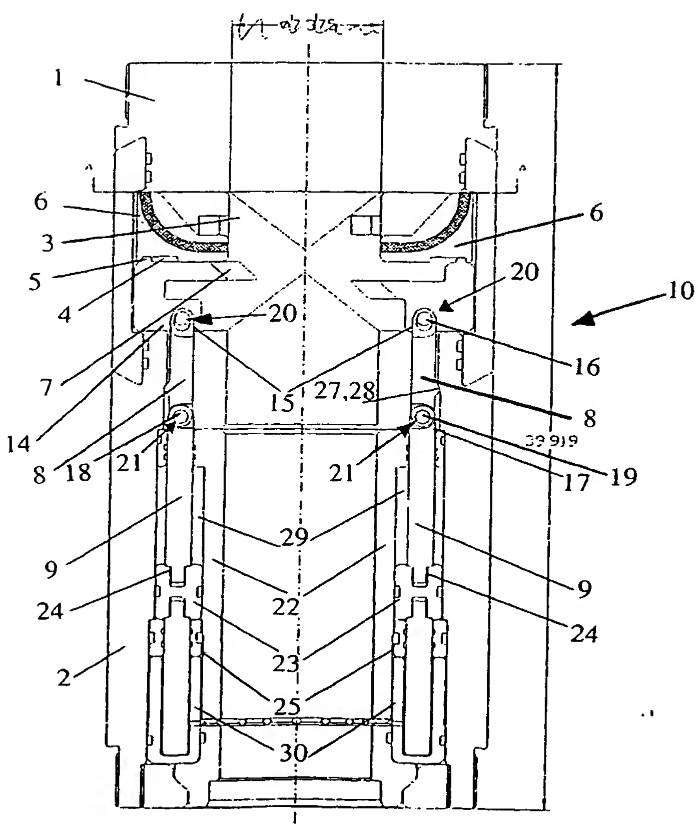
(54) Title: RISER CONTROL DEVICE



(57) Abstract: Riser control device, particularly designed to be used in connection with spool or horizontal production trees (12) for wells in sub-sea oil and gas installations. Within a housing (1, 2) of the device is provided, in opposed direction, radially movable pair of rams (6) for isolating (sealing off) the well and simultaniously, in opposed direction radially movable pair of shear blades (7) for cutting off an intervention string or the like. The rams (6) and blades (7) are driven by means of a within the housing (1, 2) vertically provided actuator (8, 9, 23). The actuator may be in the form of a hydralically driven annulor piston (23) / annular chamber (29, 30) device, which via piston rods (14) and translation beams (8) transforms the movement of the piston (23) to open or close the rams (6) and shear blades (7).

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ATTACHMENT A

Riser control device

The present invention relates to a riser control device, particularity designed to be used in connection with spool or horizontal production trees in sub-sea oil and gas installations.

The past decade has seen the use of sub-sea production systems become the method of choice for exploiting offshore oil and gas fields. The use of these systems offer significant advantages over traditional platform based method in both economics and reservoir managements terms. A significant step change in sub-sea production systems occurred with the introduction of the spool or horizontal production tree. Enabling the use of large bore completions and subsequently multi-lateral wells, the introduction of this equipment has led to a considerable reduction in the number of wells required to fully exploit an offshore field. These systems also reduce capex and opex costs by enabling completion and intervention operations to be conducted via a traditional drilling riser and BOP as opposed to the dual skeletal riser normally associated with conventional sub-sea production trees.

Many of the fields developed with horizontal trees are now moving into the 2nd phase of production and consequently the intervention phase, i.e. extensive production logging programmes followed by the diagnosed remedial operations such as re-perforating and water shutoff activity, the requirement for and difficulty of these operations is increased by the complexity of reservoirs both developed and planned. The very nature of the wells with long horizontal sections undulating through the producing section require the deployment for intervention tooling on compressively stiff coil tubing. The critical function when deploying equipment of this type in a sub-sea environment is the ability of the sub-sea LRP to cut the intervention string and isolate the well. Current well isolation

devices utilised for this service are based upon established techniques utilised in down hole safety valves, with the primary cutting device a ball valve and the primary sealing being either a ball or flapper valve.

The use of a ball valve to provide a cutting function is unique to this type of application as cutting operations are normally conducted by BOP's which offer considerable advantages, cutting efficiency being much greater and debris tolerance significantly greater providing improved sealing reliability.

A further major influence on intervention policy will be the ability to deploy the intervention system and conduct operations from a lightweight vessel.

In the formative era of the horizontal tree it was envisaged that intervention operations would be conducted from a drilling rig via a marine riser / BOP and a large bore work over riser and LRP. However, the use of a conventional vessel involves cost implications not only with high opex but also with the increased complexity of mooring in and around production facilities and infrastructure. Many studies have been conducted to establish the economic and operational integrity of conducting interventions from a lightweight semi or mono hull vessel. The size of these vessel's preclude the use of a marine riser and BOP stack, requiring the deployment of sub surface lubricator system similar to that used on conventional tree interventions. Well control during these operations is achieved by a combination of barriers contained within the intervention system and the production tree. This enables full flexibility of well containment and even the complete retrieval of the intervention equipment, the valves contained with in the vertical bore of the production tree providing well isolation.

However, when conducting similar operations on a horizontal tree with no vertical isolation capability (both tubing hanger and tree cap plugs removed to allow intervention string access) the only vertical isolation available is contained within the intervention system itself. Under normal circumstances this meets with accepted barrier philosophy but does preclude the ability to remove the intervention equipment or deploy a BOP for

well kill or fishing operations. Several different concepts to improve the integrity of horizontal tree lightweight intervention operations have been produced all allow the deployment of a drilling BOP during intervention operations, such as the use of a connector, shear ram and connector spool (the shear ram providing well isolation during intervention system running and pulling) or the deployment of a connector and spool with integral internal valve which can be hydraulically closed enabling the intervention system to be retrieved and the BOP stack to be run. Both systems, however, add considerable weight to the intervention system requiring a much larger vessel than those normally associated with lightweight intervention techniques. A further disadvantage is the bending moment induced at the production tree and wellhead is substantially increased by the weight and length of the spool and additional connector, precluding the use of this system in all but benign environments.

To avoid the above disadvantages of the above-mentioned BOP and ball valve solutions and to enable the advantages of the spool or horizontal production tree to be fully exploited the inventors developed a riser control device according to the present invention, enabling replication of the function of a conventional LRP providing both well control (safe isolation) and disconnect functions.

The original systems utilised in this role were developed from equipment introduced in the early eighties for exploration and appraisal activity's which are generally of short duration and do not require the considerable number of inventory cycles experienced in a completion environment. As a consequence the early systems utilised for this critical application did not provide the required availability, and considerable development effort was extended to produce a system to meet the availability and integrity requirements.

The invention is characterised by the features as defined in the attached claim 1.

Preferred embodiments of the invention is further defined in the attached dependent claims 2 - 5.

The invention will be further described in the following by way of example and with reference to the drawings in which:

Fig. 1 shows a longitudinal (vertical) cross sectional view of a lower part of a riser with a horizontal production tree and a conventional BOP system.

Fig. 2 shows a longitudinal (vertical) cross sectional view of the lower part of a riser with a horizontal production tree and above the tree provided riser control device according to the invention.

Fig. 3 shows an larger scale a cross sectional view of the same riser control device (figures to be corrected) – showing a top sectional as well as "side" sectional (at another cross section angle).

Fig. 4 shows sequences a), b) and c) of the riser control device from open to closed position.

Conventional BOP systems as shown in Fig. 1 feature a pair of rams 32 located in horizontally opposed pockets located at 90 degree's to the vertical (well) bore or riser 11. To close the rams move towards one another meeting at the centre of the internal bore. Circa 40% of the ram length remains in each pocket to provide structural support resisting the pressure induced end load. Sealing integrity is achieved by a continuous elastomeric seal across the face of reach ram along the horizontal diameter of the ram and across the top o/d linking with the opposite horizontal leg, the sealing integrity being achieved by the contact of the elastomeric elements in the ram faces and the ram pocket. A major disadvantage of the system is that 50% of the total ram area is exposed to differential pressure when closed thus increasing effective sealing integrity. In subsurface applications (and most surface) the rams are hydraulically actuated by pistons mounted on the axis of the ram and pocket which are connected to the outer face of each ram via an actuator rod. The area of this rod is exposed to well bore pressure and subsequently generates an axial outward (opening) force upon the system, which necessitates the

provision of some form of locking system (wedgelocks) to avoid inadvertent opening of the rams in the advent of a hydraulic failure. As can be seen a BOP system design requires a considerable width to i/d ratio to function efficiently, normally in the region of 8 to 10. It is therefor obvious despite the increased operational integrity provided by a BOP system that the external envelope precludes the use of this technology .

As stated above, Fig. 2 shows a longitudinal (vertical) cross sectional view of the lower part of a riser 11 with a horizontal production tree 12 and above the tree provided riser control device 10 according to the invention. As can be seen from the figure, the riser control device 10 is connected directly to the tree at the end of the riser below a (conventional) closing valve 13.

Reference is now made to Fig. 3, which shows the riser control device 10 according to the invention in the normal operating (open) mode. The main body is made up of two sections, the upper housing 1 and the lower housing 2. The upper housing contains the rams 6 within cavity's 3 which are formed between the interface of the upper and lower housing. Machined in the lower face of each ram is a tee shaped slot 4, which runs parallel to the axis of the ram. A mating spigot 5 is formed on the upper section of the shear blade 7 which fits into the slot 4 in the rams lower face. This enable the blade to travel freely in relationship to the ram 6 for a predetermined linear distance. The distance of travel is determined by the length of the ram spigot (slot) and depth of the back plate attached to the ram. On the opposite face of the blade to the spigot, parallel the axis of the ram, a flange is formed with a centre hole throught the flange at 90 degree's to the ram and blade axis, The blade flange fits between two identical flanges 15 formed on the upper section of the translation beam 8 and is locked in position by inserting a retainer pin 16 into the bore of all three flanges. This effectively enables linear movement of the translation beam 8 to be transferred to the blade/ram assembly whilst enabling the vertical movement of the translation beam 8 to be absorbed as rotational component.

The lower end of the translation beam 8 is identical to the upper terminating in a dual flanged yoke 17 each with a centre hole at 90 degrees to the main axis of the beam. These

flanges fit over a corresponding flange 18 formed on the upper section of the piston rod 9 and are attached by the insertion of an identical retainer pin 19 to that utilised in the upper yoke. This flange yoke assembly although identical to the upper assembly which allows the horizontal and vertical movement component to be transferred to a total horizontal movement enables the vertical movement of the piston rod 9 to be split into horizontal and vertical components.

Therefore, the combination of the two rotational hinges 20, 21 at the opposite ends of the translation beam 8 enable the vertical movement of the piston rod 9 to be transferred to a total horizontal movement of the ram/bade assembly.

The amount of vertical travel required to obtain the required horizontal component to fully open and close the rams 6 is dependant on both the length of the translation beam 8 and the initial angular offset of the rotational hinges 20, 21. It should be noted that the longer the translation beam length the less the vertical travel required to obtain the horizontal component to obtain full closure. A significant advantage of this method of operating a ram 6 as opposed to a conventional linear system is that the travel of the ram is inverse to the vertical travel of the actuator therefore providing considerable mechanical advantage during the cutting and sealing section of the stoke resulting in improved cutting and sealing integrity.

In normal operations the actuation system for the ram/cutter 6,7 is operated hydraulically, but other forms of motive force can be utilised. The hydraulic actuation system is effectively a self contained unit which is assembled externally. This allows the system to be rapidly refurbished if required. Consisting of 8 major components which can be defined as the following: inner mandrel 22, piston rod 9, annular piston 23, balance piston 24, intermediate seal carrier 25, carrier retainer 26, mandrel retainer 27, and retainer lock ring 28.

Once assembled the actuator assembly is placed into the lower housing and locked insitu by the installation of the retainer lock ring into the internal thread of the lower housing 2.

The installation of the assembly effectively forms two independent hydraulic chambers within the assembly. The upper chamber 29 is formed between the lower face of the inner mandrel 22 and the upper face of the annular piston 23. The lower chamber 30 is formed between the lower face of the annular piston 23 and the upper face of the intermediate seal carrier 25. Hydraulic conduits 31 located in the external wall of the lower housing 2 are through ported into the respective hydraulic chambers. The upper chamber 29 the opening conduit acts as the opening chamber, hydraulic pressure applied to the chamber 29 creates a differential force across the annular piston 23 creating a motive force urging the piston 23 to travel in the downwards direction.

The piston rods 9 which are attached to the annular piston 23 by means of a thread 24 consequently travel downwards pulling the lower joint of the translation beam with it, which is transferred into horizontal movement of the shear blade 7 and ram 6 assembly urging each one to the open position.

The lower chamber 30 which is fed by the hydraulic conduit acts as the closure system, hydraulic pressure applied via the conduit acts on the lower face of the annular piston 23 creating a differential pressure which translates to a motive force urging the piston 23 and consequently the piston rods 9 and lower joint 21 of the translation beam 8 upwards. The vertical movement is translated by the upper and lower joints of the translation beam to a true horizontal component therefore moving the blades and subsequently the rams to the closed position.

Fig. 4 a), b) and c) shows sequence of the riser control device from starting to fully closed position. In Fig. 4 a) the closing operation is just initiated. Initial movement of the rams 6 is accomplished by by means of spigots 27 provided on the translation beams 8. The beams 8 are pushed inwards as the spigots 27 engage against an inwardly elevating party 28 on the housing 2, whereas at the same time the beams are moved upwards by the piston 23. Fig. 4 b) shows the control device in a position where the cutting knives 7 and rams 6 are in a mid-way cutting position, while Fig. 4 c) shows the rams 6 in a fully

closed position where the resilient packing elements 31 are closing tightly against the remaining end of the production string (not shown) or the like.

The invention as defined in the claims is not limited to use in connection with cutting and sealing off a drill string or riser, but may as well be used as a conventional closing valve, without the kutting knives 7.

Claims

1. Riser control device, particularly designed to be used in connection with spool or horizontal production trees (12) for wells in sub-sea oil and gas installations, c h a r a c t e r i z e d i n within a housing (1,2) provided in opposed direction radially movable pair of rams (6) for isolating (sealing off) the well and simultaneously, in opposed direction radially movable pair of shear blades (7) for cutting off an intervention string or the like, the rams (6) and blades (7) being driven by means of a within the housing (1,2) vertically provided actuator (8,9,23).

2. Riser control device according to claim 1,
c h a r a c t e r i z e d i n that the actuator is in the form of a hydralically driven annular piston (23) / annular chamber (29,30) device, which via piston rods (14) and translation beams (8) transforms the movement of the piston (23) to open or close the rams (6) and shear blades (7).

3. Riser control device according to claims 1 and 2,
c h a r a c t e r i s e d i n that the shear blades (7) and rams (6) are reciprocally connected, whereby the radial movement of the shear blades (7) implies radial movement of the rams (6) as well.

4. Riser control device according to claim 3,
c h a r a c t e r i z e d i n that the rams (6) are provided on top of the shear blades (7), whereby the interconnection between the rams and the blades is in the form of a slot (4) in the lower face of each ram (6) and a mating spigot (5) in the upper section of the shear blade (7).

5. Riser control device according to claim 4, **characterized in** that the slot (4) extends over a distance parallel to the axis of the ram (6), whereby the respective blade (7) travels freely in relationship to the respective ram (6) over the same distance.

Fig. 1

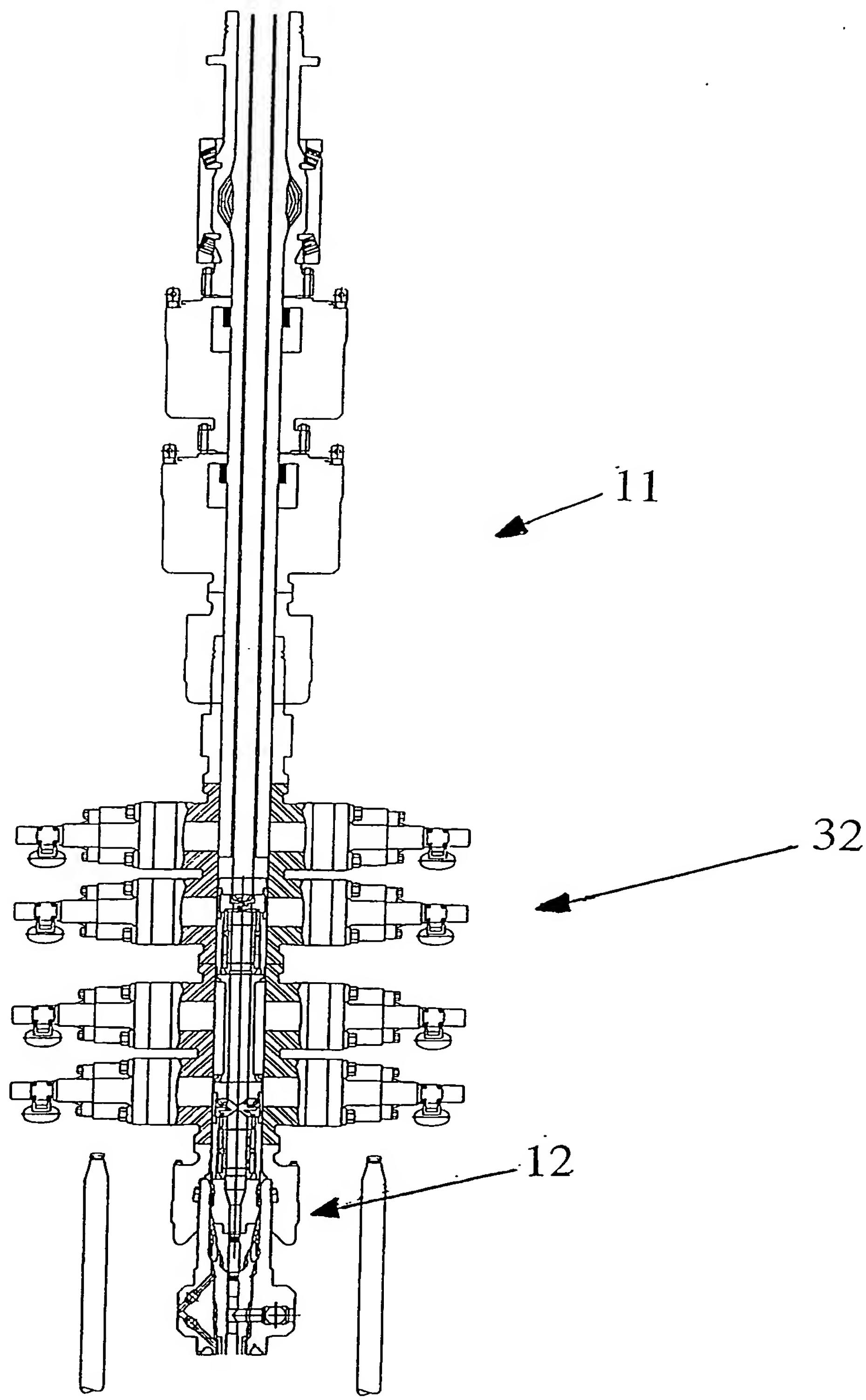

Fig. 2

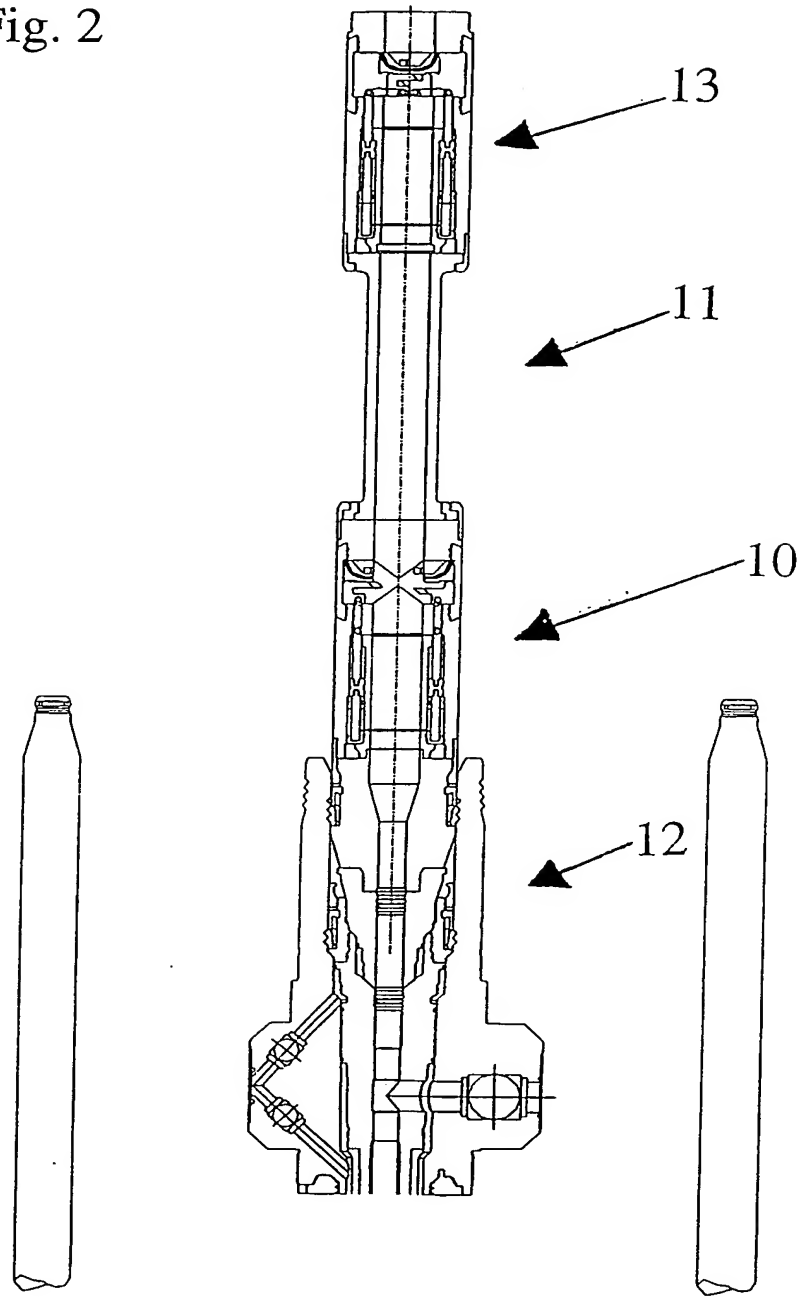

Fig. 3

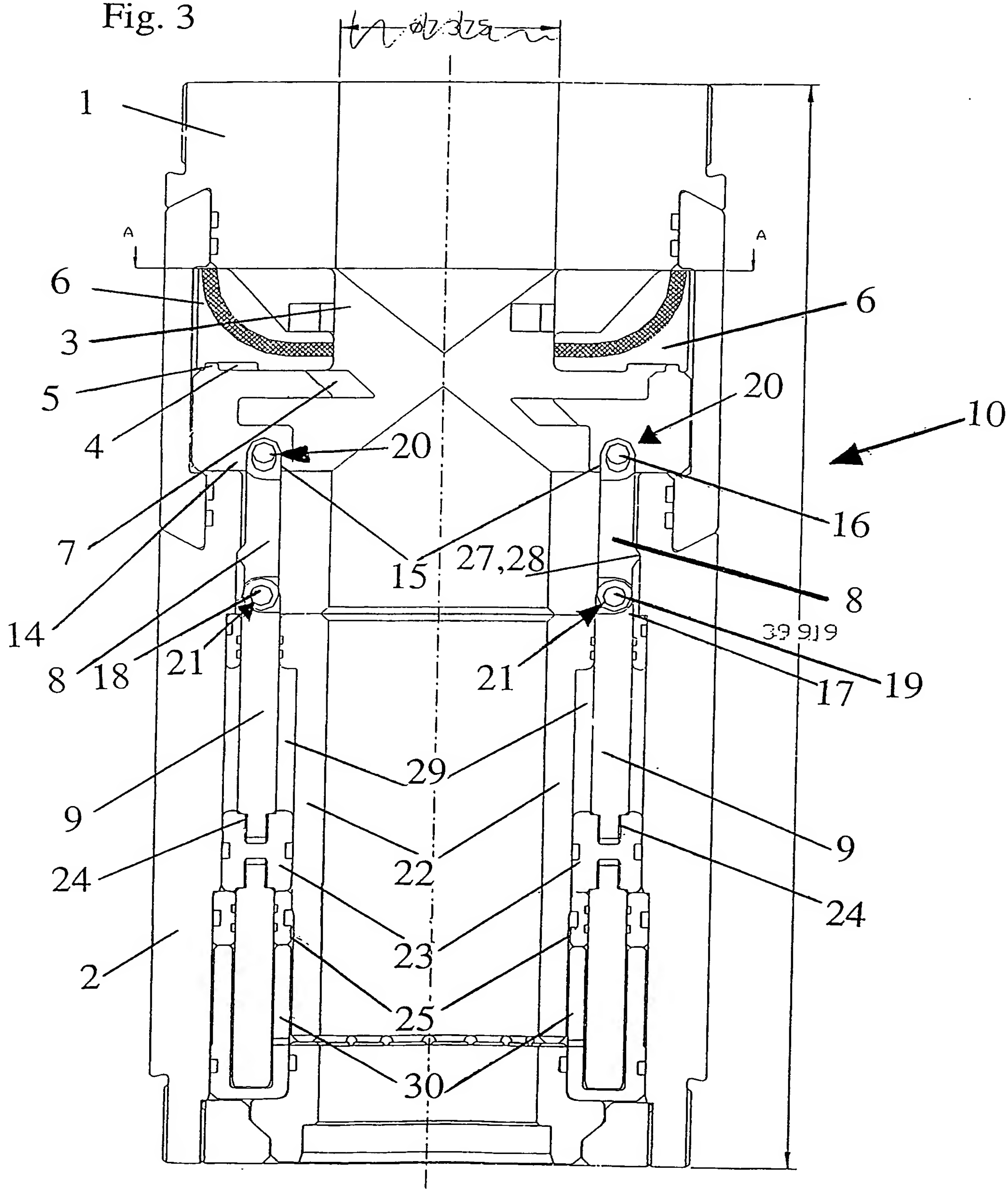
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Fig. 4 a)

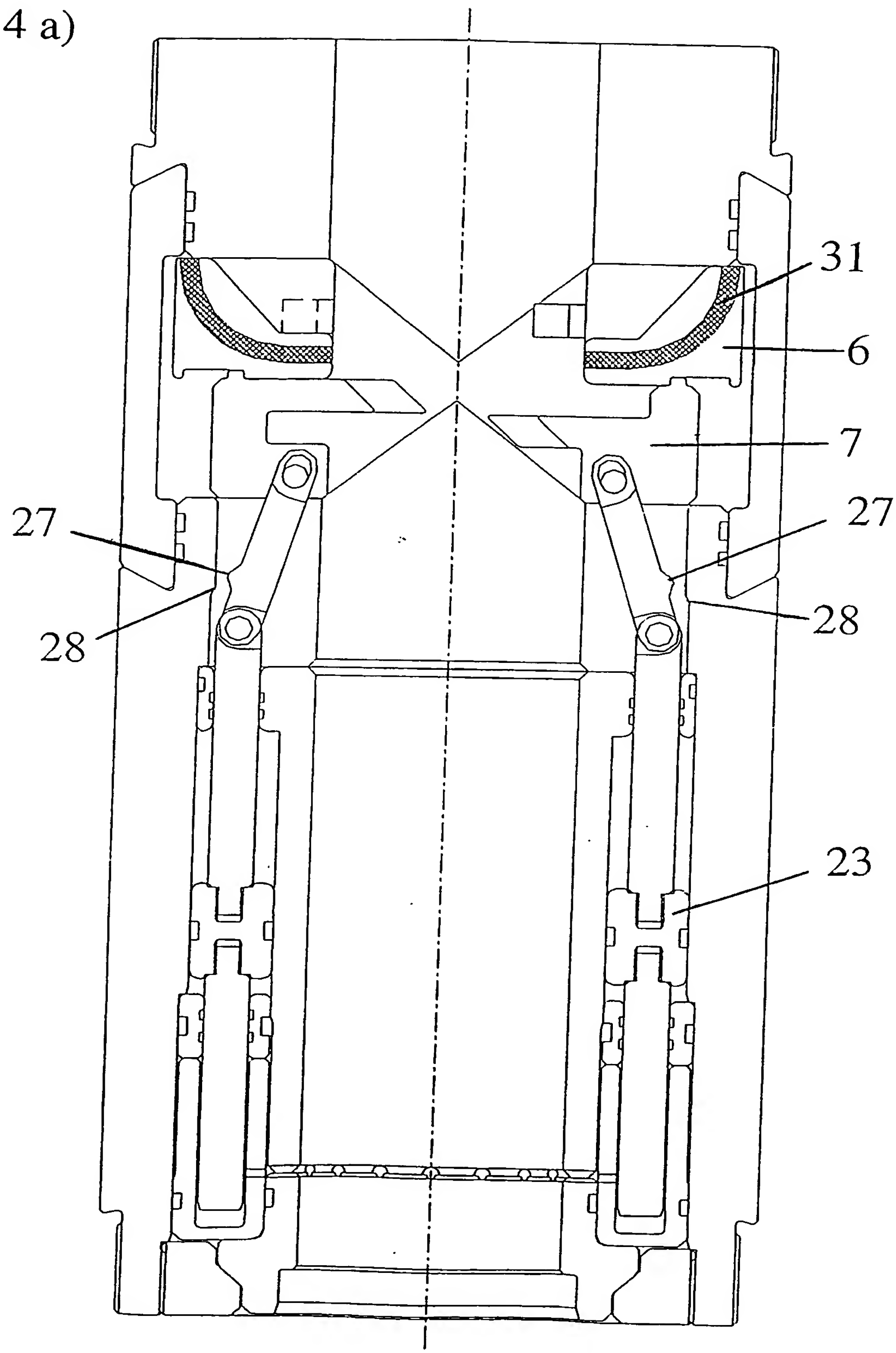

Fig. 4 b)

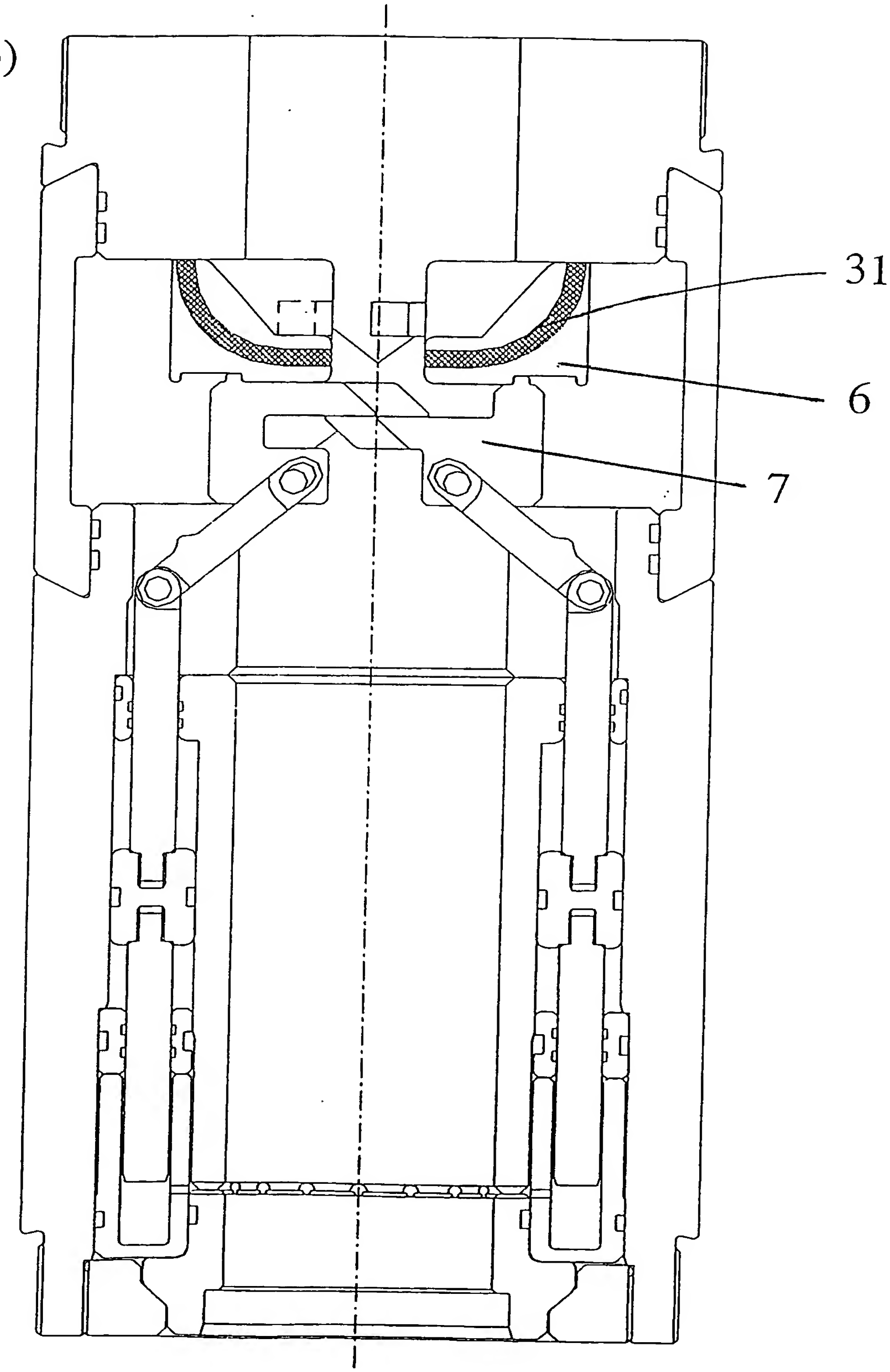

Fig. 4 c)